

What is claimed is:

1. A core used in an armature of a rotation apparatus, wherein the core includes a first piece and a second piece,
5 wherein each core piece includes:
 - a ring having a first engaging portion: and
 - a tooth radially extending from the ring, wherein the tooth includes an integral tooth member, which is integrally formed with the ring, and a separate tooth member, which has
 - 10 the same shape as the integral tooth member and is secured to the integral tooth member, wherein the separate tooth member of each core piece has a second engaging portion, which corresponds to the first engaging portion of the other core piece;
 - 15 wherein the core pieces are assembled when the first engaging portion of the first core piece is engaged with the second engaging portion of the second core piece and the first engaging portion of the second core piece is engaged with the second engaging portion of the first core piece.
- 20 2. The core according to claim 1, wherein each separate tooth member has the same dimension as the corresponding ring along the axial direction of the corresponding core piece.
- 25 3. The core according to claim 1, wherein the tooth of each core piece is one of a plurality of teeth, which are located on the circumference of the corresponding ring and are spaced at equal angular intervals, wherein the first engaging portion is one of a plurality of first engaging portions, which are
- 30 located on the circumference of the corresponding ring and are spaced at equal angular intervals, and wherein each first engaging portion is located between an adjacent pair of the teeth.
- 35 4. The core according to claim 3, wherein the number of the

teeth on each core piece is four, and wherein the number of the first engaging portions on each core piece is four.

5. The core according to claim 1, wherein an insulator is
5 attached to each tooth, wherein each insulator has a base section, which contacts the second engaging portion of the corresponding tooth, and wherein the circumferential dimension of each second engaging portion is equal to or greater than the circumferential dimension of the corresponding base
10 section.

6. The core according to claim 5, wherein the circumferential dimension of each second engaging portion corresponds to an angle that is obtained by dividing 360° by
15 the total number of the teeth.

7. The core according to claim 1, wherein an insulator is attached to each tooth, wherein each separate tooth member has a section for preventing the corresponding insulator from
20 being flexed.

8. A method for manufacturing a core used in an armature of a rotation apparatus, comprising:

25 preparing separate first and second core pieces, wherein each core piece has a ring, which has a first engaging portion, and an integral tooth member, which radially extends from the ring;

30 securing a separate tooth member, which has the same shape as the integral tooth member, to each integral tooth member, wherein each integral tooth member and the corresponding separate tooth member form a tooth, wherein the separate tooth member of each core piece has a second engaging portion, which corresponds to the first engaging portion of the other core piece;

35 winding a coil about each tooth; and

assembling the core pieces by engaging the first engaging portion of the first core piece with the second engaging portion of the second core piece and engaging the first engaging portion of the second core piece with the second engaging portion of the first core piece.

9. The method according to claim 8, comprising attaching an insulator to each tooth prior to winding the coils to the teeth, wherein, when each coil is being wound about the corresponding tooth, the corresponding separate tooth member supports the corresponding insulator for preventing the insulator from being flexed.

10. A rotation apparatus, comprising:

15 a stator having a plurality of magnetic poles;
a rotor having a plurality of teeth, the teeth being arranged to face the magnetic poles, wherein a coil is wound about each tooth;
20 a commutator secured to the rotor, wherein the commutator is connected to the coils; and
a plurality of brushes, which slidably contact the commutator;
wherein the number of the magnetic poles and the number 25 of the teeth are determined such that the rotor receives no radial force.

11. A rotation apparatus, comprising:

30 a stator having a plurality of magnetic poles;
a rotor having a plurality of teeth, the teeth being arranged to face the magnetic poles, wherein a coil is wound about each tooth;
a commutator secured to the rotor, wherein the commutator is connected to the coils; and
35 a plurality of brushes, which slidably contact the commutator;

wherein the number of the magnetic poles and the number of the teeth are determined such that the resultant of torque vectors that act on the teeth is zero.

5 12. The rotation apparatus according to claim 11, wherein the number of the magnetic poles is six, and the number of the teeth is eight.

10 13. The rotation apparatus according to claim 11, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), and the number of the teeth is represented by n (n is an integer equal to or greater than three), the number $2m$ of the magnetic poles and the number n of the teeth are determined to satisfy the
15 following formulas:

$$0 < 2m < 2n \quad (n \neq 2m) \text{ and}$$
$$\text{mod}(n, 2) = 0$$

20 14. The rotation apparatus according to claim 11, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), the number of the teeth is represented by n (n is an integer equal to or greater than three), and k is a natural number, the number $2m$ of the magnetic poles and the number n of the teeth are determined to
25 satisfy the following formulas:

$$0 < 2m < 2n \quad (n \neq 2m)$$
$$\text{mod}(n, 2) = 1$$
$$\text{mod}((\text{a factor of } n \text{ other than } 1) \times k, 2) = 0 \text{ and}$$
$$(\text{a factor of } n \text{ other than } 1) \times k = 2m$$

30 15. The rotation apparatus according to claim 11, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), and the number of the teeth is represented by n (n is an integer equal to or
35 greater than three), the short-pitch factor K satisfies the

following formula:

$$K = \sin((n/2) \times (2m/n));$$

and the number $2m$ of the magnetic poles and the number n of the teeth are determined such that the short-pitch factor K is a great value.

16. The rotation apparatus according to claim 11, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), and the number of the teeth is represented by n (n is an integer equal to or greater than three), the short-pitch factor K satisfies the following formula:

$$K = \sin((\pi/2) \times (2m/n));$$

and the number $2m$ of the magnetic poles and the number n of the teeth are determined such that the short-pitch factor K is greater than 0.9.

17. The rotation apparatus according to claim 11, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), and the number of the teeth is represented by n (n is an integer equal to or greater than three), the number H of the cogging torque pulsations is the least common multiple of the number $2m$ of the magnetic poles and the number n of the teeth, and the number $2m$ of the magnetic poles and the number n of the teeth are determined such that the number H of the cogging torque pulsations is a great value.

18. The rotation apparatus according to claim 11, wherein the rotor includes a first core piece and a second core piece, wherein each core piece includes a ring having a plurality of first engaging portions, the teeth extending radially from each ring, and wherein the teeth of each core have a plurality of second engaging portions, each of which corresponds to one of the first engaging portions of the other core piece;

wherein the core pieces are assembled when the first engaging portions of the first core piece are engaged with the second engaging portions of the second core piece and the first engaging portions of the second core piece are engaged
5 with the second engaging portions of the first core piece.

19. The rotation apparatus according to claim 18, wherein each tooth includes an integral tooth member, which is integrally formed with the corresponding ring, and a separate
10 tooth member, which has the same shape as the integral tooth member and is secured to the integral tooth member, wherein each second engaging portion is formed in one of the separate tooth members.

15 20. The rotation apparatus according to claim 18, wherein each core piece is formed from magnetic powder through compression molding such that each tooth is integrated with the corresponding ring.

20 21. The rotation apparatus according to claim 18, wherein the number of the magnetic poles is six, and the number of the teeth is eight, and wherein each coil is wound about the corresponding tooth in a concentrated manner.

25 22. The rotation apparatus according to claim 18, wherein the commutator includes a substantially cylindrical insulator and a plurality of segments arranged about the insulator, wherein each end of each coil is connected to one of the segments, and wherein each of the segments that are not connected to the
30 coils is connected to two of the segments that are connected to the coils by a short-circuit line.

23. The rotation apparatus according to claim 22, wherein each short-circuit line connects one of the segments that are
35 not connected to the coils with two other segments that are

spaced from the one segment in the opposite directions along the circumference of the commutator.

24. The rotation apparatus according to claim 22, wherein the
5 center portion of each short circuit line is bent, wherein the bent portion is connected to one of the segments that are not connected to the coils, and wherein the ends of each short-circuit line is connected to two of the segments that are not connected to the coils.

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25. A rotation apparatus, comprising:

a rotor having a plurality of magnetic poles;

15 a stator having a plurality of teeth, the teeth being arranged to face the magnetic poles, wherein a coil is wound about each tooth;

wherein the number of the magnetic poles and the number of the teeth are determined such that the rotor receives no radial force.

20 26. A rotation apparatus, comprising:

a rotor having a plurality of magnetic poles;

25 a stator having a plurality of teeth, the teeth being arranged to face the magnetic poles, wherein a coil is wound about each tooth;

wherein the number of the magnetic poles and the number of the teeth are determined such that the resultant of the torque vectors that act on the teeth is zero.

30 27. The rotation apparatus according to claim 26, wherein the number of the magnetic poles is six, and the number of the teeth is eight.

35 28. The rotation apparatus according to claim 26, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), and the number of

the teeth is represented by n (n is an integer equal to or greater than three), the number $2m$ of the magnetic poles and the number n of the teeth are determined to satisfy the following formulas:

5 $0 < 2m < 2n \quad (n \neq 2m)$ and
 $\text{mod}(n, 2) = 0$

29. The rotation apparatus according to claim 26, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), the number of the teeth is represented by n (n is an integer equal to or greater than three), and k is a natural number, the number $2m$ of the magnetic poles and the number n of the teeth are determined to satisfy the following formulas:

15 $0 < 2m < 2n \quad (n \neq 2m)$
 $\text{mod}(n, 2) = 1$
 $\text{mod}((\text{a factor of } n \text{ other than } 1) \times k, 2) = 0$ and
 $(\text{a factor of } n \text{ other than } 1) \times k = 2m$

20 30. The rotation apparatus according to claim 26, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), and the number of the teeth is represented by n (n is an integer equal to or greater than three), the short-pitch factor K satisfies the following formula:

$$K = \sin((n/2) \times (2m/n));$$

and the number $2m$ of the magnetic poles and the number n of the teeth are determined such that the short-pitch factor K is a great value.

30 31. The rotation apparatus according to claim 26, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), and the number of the teeth is represented by n (n is an integer equal to or greater than three), the short-pitch factor K satisfies the

following formula:

$$K = \sin((\pi/2) \times (2m/n));$$

and the number $2m$ of the magnetic poles and the number n of the teeth are determined such that the short-pitch factor K is greater than 0.9.

32. The rotation apparatus according to claim 26, wherein, when the number of the magnetic poles is represented by $2m$ (m is an integer equal to or greater than one), and the number of the teeth is represented by n (n is an integer equal to or greater than three), the number H of the cogging torque pulsations is the least common multiple of the number $2m$ of the magnetic poles and the number n of the teeth, and the number $2m$ of the magnetic poles and the number n of the teeth are determined such that the number H of the cogging torque pulsations is a great value.

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